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Request for grant of a patent

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1. **Your reference** — 44.68819/000

2. **Patent application number** *(The Patent Office will fill in this part)* — **9904162.6**

3. **Full name, address and postcode of the or of each applicant** *(underline all surnames)*

   Austevoll Fiskefôr AS
   N-5392 Storebø
   Norway

   Patents ADP number *(if you know it)* — 7608516001

   If the applicant is a corporate body, give country/state of incorporation — Norway

4. **Title of the invention** — Process

5. **Name of your agent** *(if you have one)* — Frank B. Dehn & Co.

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

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   London
   EC4V 4EL

   Patents ADP number *(if you know it)* — 166001

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. **If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application**

Number of earlier application	Date of filing *(day / month / year)*

8. **Is a statement of inventorship and of right to grant of a patent required in support of this request?** *(Answer 'Yes' if:*
   a) any applicant named in part 3 is not an inventor, or
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	Continuation sheets of this form	0
	Description	12
	Claim(*s*)	1
	Abstract	-
	Drawing(*s*)	3 + 3
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	Priority documents	-
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	Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
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11.		I/We request the grant of a patent on the basis of this application. Signature Date 23 February 1999 Frank B Dehn & Co
12.	Name and daytime telephone number of person to contact in the United Kingdom	Julian Cockbain 0171 206 0600

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Process

The present invention relates to a process for the preparation of a fish-based fodder and to the fodder so prepared.

Aquaculture, sometimes referred to as fish farming, is a rapidly growing industry and provides an increasing demand for fish-feed, ie. fodder. Currently major components of fish-feed are marine proteins (in the form of fish meal) and marine oils (in the form of fish oils).

The term "feed" is generally used in the art to describe a product which meets the daily nutritional needs of the creature being fed with it, ie. it contains all the essential nutrients. The term "feedstuff" in comparison is used to refer to a component of the complete feed, e.g. a protein or fish oil or a component containing the necessary proteins and oils but without the proper vitamin content. As used herein, the term "nutritional composition" includes both complete feeds and feedstuffs.

In aquaculture, in particular salmon and catfish farming, fodder pellets are used as feed. These pellets are usually made from fish meal and fish oil and result in a more efficient use of the raw material. Thus for example 10 kg of capelin used directly as food for cod leads to generation of about 2 kg of cod corresponding to about 0.7 kg of cod fillets. If instead 10 kg of capelin is processed to produce fish meal and fish oil and used as fodder for farmed salmon, the yield is about 4.6 kg salmon or 2.8 kg salmon fillet. The energy yield moreover is significantly greater: the cod fillet corresponds to about 3 MJ while the salmon fillet corresponds to about 28 MJ.

The fish meal and the fish oil are produced by cooking the raw material (fish), and pressing the cooked

material to separate it into three fractions: water; fish oil; and protein. The protein fraction, the dried solid remnant of the cooking and pressing process, is about 70% protein, 10% fat and 10% water and is milled to produce fish meal. The oil fraction can be used directly for animal/fish feed production or alternatively may be purified and used for human consumption.

While it is termed fish oil, a more accurate term is perhaps lipid; both terms will be used below.

In the production of feed pellets, fish oil, optionally together with plant oils, is sprayed onto pellets formed from fish meal, optionally together with plant carbohydrates. In this way pellets with a lipid content of up to about 35% by weight can be produced. Ideally, the lipid content should be higher for optimal growth promotion in farmed fish such as salmon. However in warm temperatures, for example those experienced in summer, there is significant leakage of lipids from the feed pellets - a 500 kg sack might release as much as 30 to 50 kg of lipids. Not only is this wasteful of fish oil, since the released oil will not be consumed by the fish, but it results in the fodder being messy and difficult to handle, it results in clogging of automatic feeding systems (which often rely on pneumatic feed distribution) and it is environmentally undesirable as it puts oil onto the water surface.

Moreover, processing the raw material (fish) to separate out fish meal and fish oil and then recombining these to produce feed pellets involves a considerable usage of energy and equipment.

An alternative process for fish fodder production has been described in NO 903175 (Hamre). In this process the raw material, e.g. whole fish, fish heads, fish entrails, etc., is ground up, mixed with wheat meal, pelletized and then cooked in a microwave oven to produce pellets which float in water and which have a

moisture content of 10 to 30%. The microwave cooking coagulates the protein and prevents the pellets from coalescing - however the problem of lipid release is not overcome and the water content is undesirably high unless the pellets are to be used immediately. For storage-stable fish feed pellets, the water content is desirably below 10% by weight.

We have now found that improved feed and feedstuff pellets can be produced if, before cooking, the raw mixture is emulsified, e.g. to a mayonnaise-like consistency. If this is done, the lipid content can be increased without lipid leakage problems and storage-stable pellets with a low water content can be produced.

Viewed from one aspect therefore the invention provides a process for the production of a nutritional composition, said process comprising emulsifying a material comprising raw fish and heating the resulting emulsion to coagulate protein therein.

In the process of the invention, the raw fish used may be whole fish or parts of fish, e.g. entrails, heads, tails, etc., for example the waste material from fish filleting or gutting. Fish of the same species as the intended consumers of the nutritional composition are not recommended for use as the raw fish.

Besides the raw fish, other substances may be included in the material which is emulsified, e.g. fish meal, fish silage (hydrolysed fish), plant carbohydrate (e.g. wheat meal, corn meal, etc.), fish oil, plant oil, colouring agents, vitamins, minerals, pharmaceuticals (e.g. antibodies, growth promoters, etc.), and plant proteins, especially storage proteins and most particularly gluten.

These additional substances may serve to provide a balanced diet for the creatures fed with the nutritional composition, e.g. the vitamins and minerals; they may serve to adjust the lipid/protein balance, e.g. where the raw fish used is low in lipids, fish or plant oils

may be used to increase lipid content; they may, like the colouring agents, be used to make the flesh of farmed fish more closely resemble that of wild fish, which is particularly desirable for farmed salmon; or they may serve to improve or protect the health of the creature receiving the feed, e.g. where antibiotics are used. The use of plant storage proteins, in particular gluten, however is especially desirable as it significantly and surprisingly improves the texture, physical strength and lipid retention ability of the cooked product.

Thus with such additional substances included, the product of the process of the invention is in one preferred embodiment, a complete feed, especially a feed in pellet form.

The material which is emulsified and heated should have a sufficiently high protein content to be coagulatable on heating. Typically the protein content will be 30 to 60% by weight, e.g. 35 to 55%, preferably 38 to 45%, most preferably about 40% on a dry weight basis. Of this, up to 100% may be fish protein, preferably at least 50% deriving from the raw fish. However up to 50% by weight of the protein may be plant protein, preferably gluten. Gluten especially preferably contributes 5 to 40%, more preferably 10 to 30% and most preferably 15 to 25% by weight of the total protein. Gluten is preferably used as such, ie. as gluten rather than only in carbohydrate-containing wheat flour.

The mixture which is emulsified and coagulated will preferably have a lipid content of 15 to 55% by weight on a dry weight basis, more preferably 20 to 40%. This may derive completely from the raw fish; however typically up to 25% of the total lipids may derive from added plant or fish oils. Suitable plant and fish oils include oils from cod, capelin, herring, sprat, blue whiting, sand eel, Norwegian pout, soy, oilseed rape,

mustard seed, sunflower, safflower, etc.

Vitamins, colouring agents, pharmaceuticals and minerals will generally form only a minor portion of the mixture which is to be emulsified and coagulated, e.g. up to 10% by weight on a dry solids basis. Appropriate amounts can readily be calculated from the appropriate dosages and feed consumption rates for the creatures receiving the feedstuff.

Carbohydrates, e.g. digestible plant starch, for example wheat starch, will generally constitute up to 20% by weight on a dry weight basis of the mixture which is emulsified and cooked, preferably 5 to 15%.

The water content of the mixture to be emulsified and cooked will generally be in the range 55 to 75% by weight, preferably 60 to 70%. After cooking and drying, this will preferably be reduced to 0.5 to 70%, especially preferably 2 to 10% and more particularly 3 to 8% where the feedstuff is to be stored before use.

In the process of the invention, the mixture to be emulsified is preferably prepared by grinding up, chopping or mincing the raw fish, for example whole herring, sprat, mackerel or capelin, and then mixing in the extra substances, e.g. wheat starch, vitamin mix, gluten (e.g. from wheat and/or maize) and colouring agents (e.g. astaxanthin or cantaxanthin for salmon feed). This coarse mixture is then emulsified, e.g. using a microcutter such as the Simo Microcutter MC250/115 PFVB175SS from Simo Industries A/S of Denmark. In the Simo Microcutter, the mixture is fed at up to 6 tonne/ hour through die plates with 4 and 2.5 mm apertures and emulsified by rotating knife plates. The resulting emulsion contains oil droplets of about 1 to 50 μm maximum dimension (e.g. diameter) and is substantially free of larger solid particles, ie. particles larger than 50 μm, other than bone fragments which typically may be 200-500 μm. Typically the proportion (e.g. by volume) of solid particles (other

than bone fragments) larger than 5 μm visible by light microscopy is less than that of oil droplets of this size or larger, for example by a factor of at least 10, more usually at least 100. As mentioned above, the emulsion typically has a mayonnaise-like consistency. Viewed by light microscopy this appears to have all or substantially all of the components of the mixture as a continuous aqueous phase or a discontinuous oil phase. This is readily distinguished from the pre-emulsification mixture produced by chopping and grinding in which solid particles deriving from the raw fish, in particular muscle fibres and large bone fragments, are a prominent feature and lipid droplets are larger than in the emulsion.

After emulsification, the mixture is preferably exposed to a partial vacuum (e.g. 0.1 to 0.9 bar) to reduce the amount of entrained gas. This avoids the production of a feed which will float in water as floating feeds are not desired by salt water fish farmers. Moreover this reduces the oxygen tension (ie. oxygen content) and thereby reduces oxidation of the lipids in the composition. For catfish farming however a floating feed is desirable and degassing may be omitted or performed less completely. The final feedstuff desirably has a density in excess of 0.6 g/mL, preferably in excess of 1 g/mL, more preferably in excess of 1.2 g/mL.

Following emulsification, and if desired degassing, the emulsion is heated to coagulate the proteins and generate a lipid-retaining matrix. This may be done in several ways, e.g. by passage over a heated surface, by passage through a hot air dryer, by steam heating, by heating with electromagnetic radiation, by infra red heating, etc. However microwave heating is preferred.

In the heating step, the temperature and time of heating should be at least sufficient to coagulate the protein and create a matrix which encapsulates the

lipid. It is not necessary that heating be effected such as to significantly reduce the water content of the mixture. In general, the mixture should be brought to a temperature in the range 50 to 100°C, preferably above 78°C.

The necessary extent of heating is readily determined in practice - with too little heating pellets of the emulsion are soft and deformable, and they stick together and coalesce. With sufficient heating, such pellets are self-supporting, transportable and non-coalescing. Too much heating is unproductive as it destroys protein quality and lowers the nutritional value of the feedstuff.

The heating step which coagulates the protein is preferably effected using electromagnetic (e.g. microwave) irradiation, e.g. at a frequency in the range 10 to 3000 MHz, preferably in the range 900 to 950 MHz. The irradiation intensity is preferably in the range 0.025 to 0.5 kW per kg/hour of emulsion throughput, especially 0.05 to 0.2 $kW/kg.h^{-1}$, more especially 0.075 to 0.15 $kW/kg.h^{-1}$. The use of microwave frequencies of 900 to 950 MHz, especially about 915 MHz is preferred to the use of higher frequencies due to the increased ability to penetrate the emulsion.

Desirably the water content is reduced as little as possible during the coagulation step, with further drying to the desired final moisture content being carried out in subsequent treatment steps, e.g. using hot air drying. For dry, storage stable feed, the final moisture content is preferably less than 10% by weight; however for feed for use without storage, moisture contents of up to 30% are acceptable. Moisture content may be determined conventionally, e.g. using an infra-red moisture analyser such as a Mettler Toledo HR73 Halogen Moisture Analyser.

Before the coagulation step, the emulsion is preferably extruded or otherwise formed into sheets, or

more preferably "ropes" of 2 to 40 mm thickness, especially ropes of 3 to 25 mm diameter. If desired the emulsion may be formed in "pellets"; however it is generally preferred to cut such ropes into pellets after coagulation. Such pellet sizes may be for example 2 to 30 mm, preferably 3 to 20 mm.

If extruded or otherwise formed as sheets, the coagulated emulsion may be broken into flakes, cut into strips or otherwise transformed into particles of the desired size.

In one particularly preferred embodiment, the nutritional composition is a feedstuff produced in relatively fine grained form, e.g. pellets of 2 to 5 mm size, substantially free of plant carbohydrates and plant oils. These granules may then be used as an ingredient in the preparation of feed pellets by conventional methods, e.g. by pelletization or extrusion with binders and plant carbohydrates and addition of fish and/or plant oils and other substances as discussed above (e.g. vitamins, pharmaceuticals, coloring agents, etc). The addition of fish and plant oils may be performed so as to achieve a desired balance of fatty acid residues (e.g. of ω-3 and ω-6 acids) in the final product, which can be used as a human or animal (e.g. mammal, fish, reptile, etc.) feed or food supplement.

Particularly desirably, the emulsion is formed, e.g. into sheets or ropes, before coagulation; coagulated; cut into pellets or strips or smaller sheets; dried on a perforated belt in a multi-sector hot air dryer; and if desired broken into flakes. Especially preferably the emulsion is extruded into ropes before coagulation, coagulated, cut into pellets and then dried on a perforated belt in a multisector hot air dryer. In one preferred embodiment, in an early sector of the multi-sector dryer, air flow is through the belt from below so as to separate the pellets while in a later sector air flow is through the belt from

above so as to enhance the drying effect. Desirably a still later sector is arranged to cool the dried pellets.

The dryer used in the apparatus of the invention is conveniently a multi-sector dryer such as those produced by Lindauer Dornier GmbH, Lindau, Germany for drying of pelletized sewage sludge.

Where the product of the process of the invention is a feedstuff, a wide range of dryers may be used, e.g. multisector dryers as described above, hot air drum dryers, flash dryers, etc.

After drying and cooling, the nutritional composition may be packaged for storage or transport, e.g. in water-proof plastics containers such as sacks or drums.

The nutritional composition produced using the process of the invention is novel and forms a further aspect of the present invention. Viewed from this aspect the invention provides a nutritional composition produceable by emulsifying, coagulating and if desired drying a mixture containing raw fish.

Viewed from a further aspect the invention provides a nutritional composition containing fish oil and coagulated fish protein which is substantially free of muscle fibre fragments in excess of 200 μm in length, preferably a gluten-containing composition.

The apparatus used in the process of the invention is also novel and forms a further aspect of the invention. Viewed from this aspect the invention provides apparatus for production of a nutritional composition, said apparatus comprising:

a grinder arranged to produce a ground raw fish mixture;

an emulsifier arranged to convert the ground raw fish mixture into an emulsion;

a heater arranged to coagulate the emulsion; and

a dryer arranged to dry the coagulated emulsion.

Such apparatus preferably also comprises: a mixer to mix into the ground raw fish mixture other optional components such as vitamins, oils, minerals, gluten, starch, etc; a degasser to reduce the gas content of the emulsion; means for forming the emulsion into a desired form for coagulation in the heater, e.g. a spreader to produce sheets or an extruder to produce an emulsion extrudate; and a cutter to cut the coagulated emulsion into a desired form, e.g. a pelletizer to pelletize the coagulated emulsion.

Embodiments of the process, apparatus and products of the invention will now be described further by way of example and with reference to the following non-limiting Example and to the accompanying drawings, in which:

Figure 1 is a schematic layout for an apparatus for the performance of the process of the invention;

Figures 2 and 3 are photomicrographs of emulsions used in the process of the invention; and

Figure 4 is a photomicrograph of a raw fish mixture that has been subjected to grinding and chopping but not emulsification.

Referring to Figure 1, there is shown an apparatus 1 for the performance of the process of the invention. Raw fish (e.g. whole herring) is transferred from receiving hopper 2 to a grinder 4 by screw feed 3. The ground fish is fed from grinder 4 to screw mixer 6 by screw feed 5. In screw mixer 6, a carbohydrate (wheat starch), pigment, gluten and vitamin mixture from hopper 7 is mixed with the ground fish and the resultant mixture is passed to a buffer mixer tank 8. The mixture from tank 8 is pumped by pump 9 into an emulsifier 10 where it is emulsified. The emulsion is passed into suction silo 11 and vacuum tank 12 where it is degassed at a pressure of 0.7 bar. The degassed emulsion is pumped by pump 13 into extruder 14 which extrudes 12 mm diameter emulsion ropes onto a conveyor belt 15. Conveyor belt 15 transports the ropes of degassed

emulsion through three heating sectors of a microwave oven 16 operating at 915 MHz. Water vapour from the oven is removed and condensed. The coagulated ropes leaving oven 16 are cut into pellets by cutter 17 and the pellets are transported into a seven-sector dryer 19 by belt 18. In the first three sectors of dryer 19, hot air is passed upwards through the perforated belt 20 carrying the pellets, and in the subsequent four sectors hot air is passed downwardly through the perforated belt. In a final sector, cool air is passed between the pellets and the dried and partly cooled pellets are subsequently sieved, cooled and bagged.

Example 1

The following materials are used to produce an emulsion for feeding to a microwave oven in an apparatus according to Figure 1:

Raw whole herring	100 parts by weight
Gluten	5.13 parts by weight
Wheat starch	4.30 parts by weight
Vitamin mixture	0.08 parts by weight
Colouring agent	0.02 parts by weight

Photomicrographs of an emulsion of raw fish and carbohydrate produced in this way are shown in Figures 2 and 3. As can be seen, the emulsion contains oil droplets of 1-50 μm size. By way of comparison, from Figure 4 it may be seen that grinding and chopping raw fish, as in the procedure of Hamre (supra), does not produce such an emulsion.

The emulsion flow at 500 kg/hr is subjected to 75 kW microwave irradiation at 915 MHz, pelletized and dried to a moisture content of 7%. The resulting feed pellets show negligible lipid leakage.

Claims

1. A process for the production of a nutritional composition, said process comprising emulsifying a material comprising raw fish and heating the resulting emulsion to coagulate protein therein.

2. A nutritional composition formed by emulsifying, coagulating and if desired drying a mixture containing raw fish.

3. An apparatus for production of a nutritional composition, said apparatus comprising:

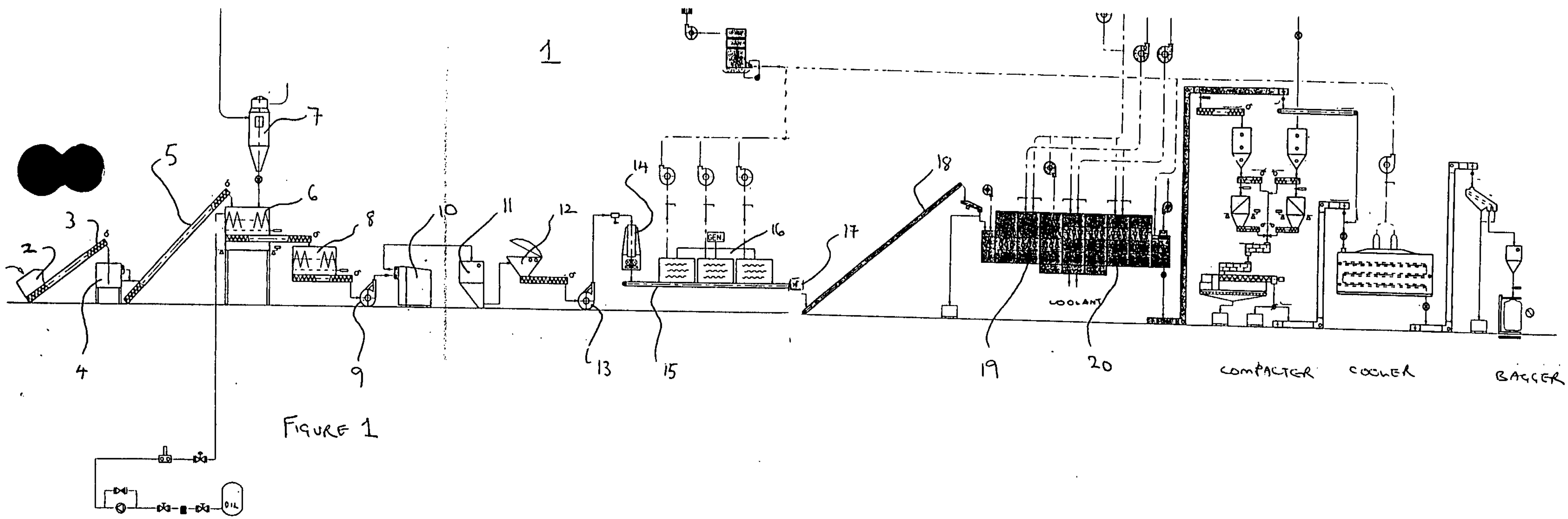
a grinder arranged to produce a ground raw fish mixture;

an emulsifier arranged to convert the ground raw fish mixture into an emulsion;

a heater arranged to coagulate the emulsion; and

a dryer arranged to dry the coagulated emulsion.

4. A nutritional composition containing fish oil and coagulated fish protein which is substantially free of muscle fibre fragments in excess of 200 μm in length.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COOLANT
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COMPACTER
COOLER
BAGGER

FIGURE 1

1/3

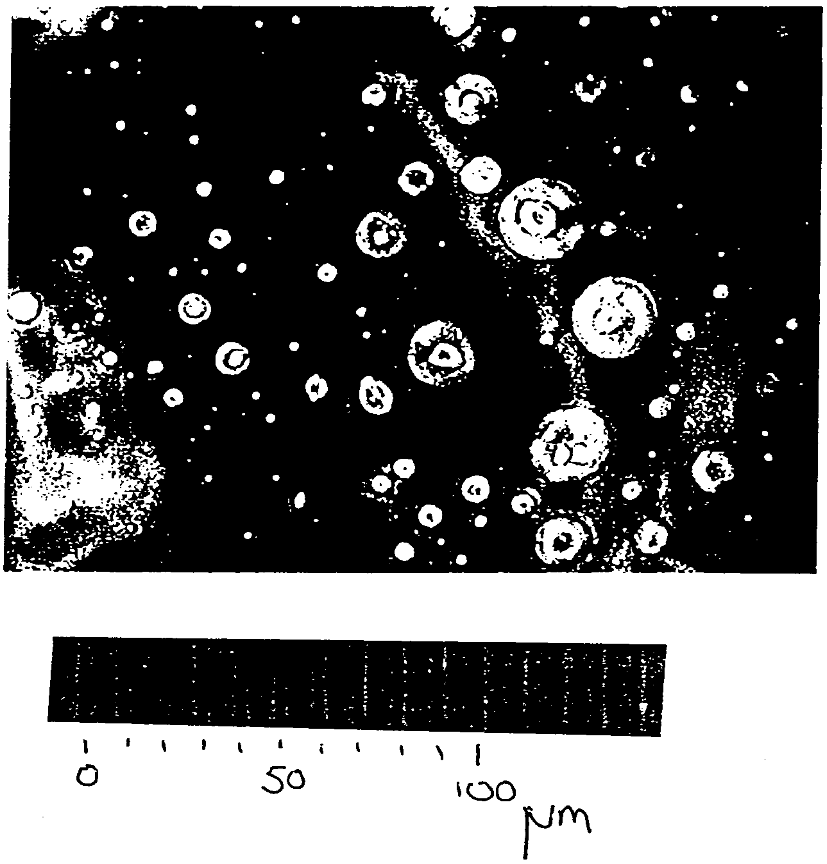

FIGURE 2

FIGURE 3

EACH STEP = 10µ

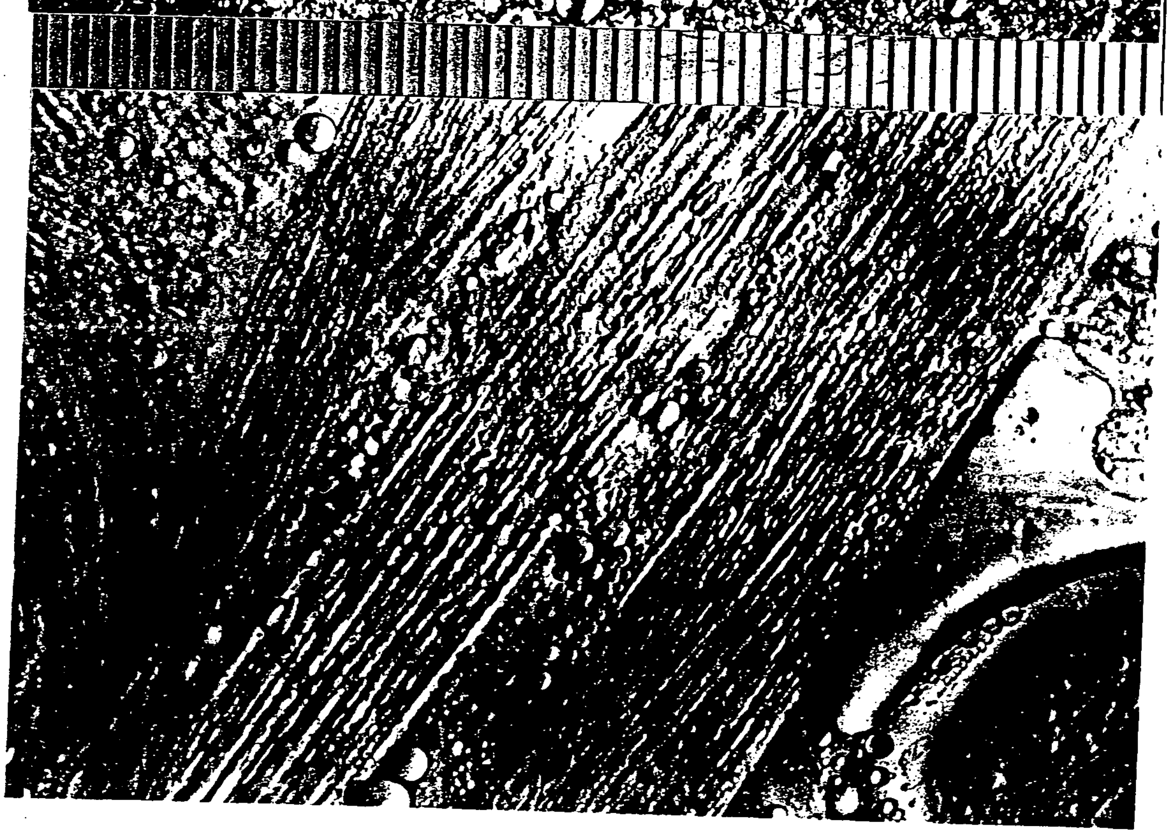

FIGURE 4

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